

Wood-polymer composites (WPCs) can be described as materials consisting of polymer matrix and wood or other plant-based fillers. Despite their popularity, over the years, researchers are trying to address their three main processing problems: (i) variations in quality of plant-based materials; (ii) limited thermal stability of plant-based materials; (iii) limited compatibility between hydrophobic polymer matrix and hydrophilic fillers. The first issue concerns the nature of plant-based materials and the structural differences associated with their origin and processing. Their structure and composition fluctuate within a certain range, which requires narrowing implying the need for proper modifications. The insufficient thermal stability limits the choice of polymers potentially applied as matrices for WPCs. Numerous works indicate the melt blending temperature of 200 °C as the upper threshold for processing, limiting the application of engineering plastics, commonly used for more demanding applications. To avoid filler degradation during melt blending, resulting in uncontrolled darkening of material, porosity generation, and loss of composites mechanical performance, fillers' pre-treatments are required to remove components characterized by insufficient thermal stability. The low level of composite components compatibility is also a critical issue, as strong interfacial interactions are crucial for achieving satisfactory mechanical properties. The compatibility may be enhanced by providing additional chemical bonding between the filler and polymer or changing the character of the fillers' surface from hydrophilic to hydrophobic to match the desired polymer matrix and increase their mutual affinity.

Except for the interfacial compatibility, other WPCs' problems, biomass diversity, and limited thermal stability are primarily associated with the presence of hemicellulose and various low-molecular-weight components. To overcome the limitations, these compounds should be removed. Such an approach often involves time-consuming procedures and the use of solvents, which contradicts the Principles of Green Chemistry. Therefore, instead of avoiding natural fillers' decomposition during melt processing by additional treatments, the procedure of their degradation out of melt blending and proceeding it by torrefaction with conditions selected for the target temperature profile prior to WPC's melt mixing is proposed in the project. Developing a thermomechanical plant-based materials modification method will provide new possibilities for applying natural fillers in WPCs, including with high-temperature processed polymers. Introducing plant-derived fillers with defined and temperature-stable structures and functional properties is the greatest challenge and objection limiting their use.

Regardless of the language or dialect used, the word degradation has a pejorative connotation and suggests deterioration of properties. Since the essence of science is to question the current state of knowledge constantly, the main question behind the presented project is a question of the true essence of the plant-based materials' degradation process: "Can thermal, mechanical, or thermomechanical degradation of plant-based materials yield beneficial changes in their structure or properties broadening their application potential in polymer composites?"

The goal of the presented project is to perform a comprehensive investigation of the phenomena occurring during the thermomechanical modification of plant-based materials. The research plan described in the project assumes three step realization conception: (i) describing the impact of temperature and mechanical treatment on plant-based materials degradation mechanism and kinetics and connecting it to their chemical composition and structure, (ii) design based on material data, and development of a prototype experimental stand, whose hearth will be a single-screw extruder for thermomechanical conversion of plant-based materials into functional fillers, with simultaneous on-line analysis of their degradation process; (iii) verification of the applicability of thermomechanically modified plant-based fillers for the production of technical polymer-based composites and as functional fillers of biopolymers with antioxidant and antimicrobial activity. A deeper understanding of degradation processes and the possibility of performing them in a controlled manner, thanks to developing a new type of single screw extruder-based and on-line monitored experimental stand, will boost their structure and performance, enabling more efficient use for developing sustainable polymeric composites. Precisely modified plant-based materials will be able to partially substitute synthetic additives commonly applied in polymer materials, such as antioxidants or stabilizers.